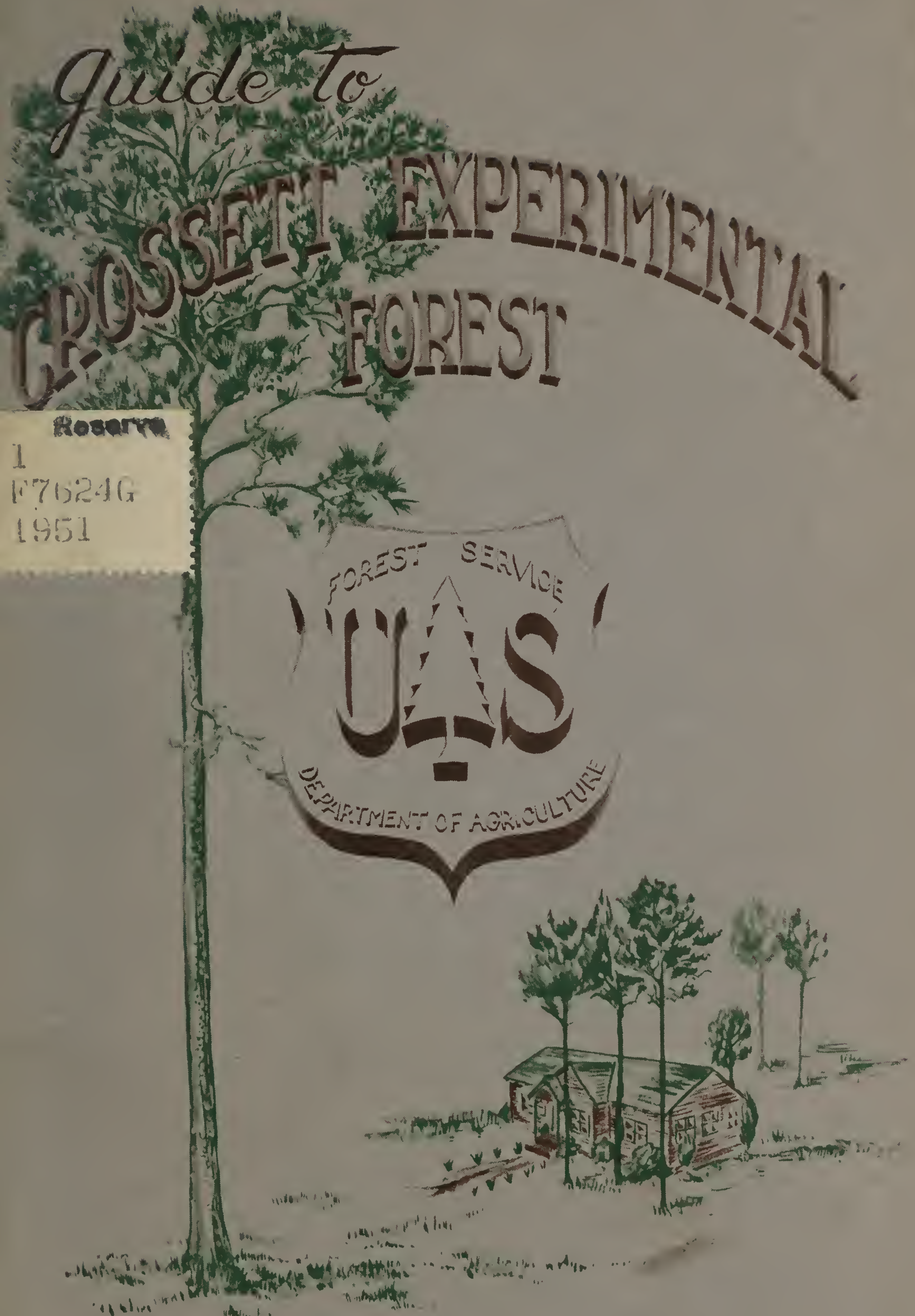
Guide to Crossett Experimental Forest



GUIDE TO THE CROSSETT EXPERIMENTAL FOREST

Southern Forest Experiment Station
New Orleans, La.

U. S. DEPARTMENT OF AGRICULTURE
FOREST SERVICE

FOREWORD

The Crossett Experimental Forest is maintained by the Forest Service, U. S. Department of Agriculture. It was established in 1934 and is the oldest of nine Branch Stations of the Southern Forest Experiment Station, whose headquarters are in New Orleans, Louisiana. The total area of the forest is 3,480 acres, all either donated or leased to the Federal Government by the Crossett Lumber Company, Crossett, Arkansas.

The Experimental Forest is an upland second-growth stand of shortleaf and loblolly pine mixed with hardwood. It is typical of the average to better stands that have developed since the virgin timber was cut in 1915. Loblolly pine makes up about 80 percent of the present pine portion of the stand and shortleaf pine the remaining 20 percent. Before management began in 1934, hardwoods were about as numerous as pine. Southern red oak, sweetgum, post oak, white oak, blackgum, hickory, and water oak were the most prevalent and most important hardwood species. Hardwoods now make up about 15 percent of the total merchantable volume on the Forest.

The Crossett Experimental Forest has been developed with three principal objectives in view. The first is to learn how to manage the understocked stands so as to get the maximum returns possible at present and at the same time to build up the growing stock so as to get still greater returns in the future. The second objective is to provide an experimental area or field laboratory for research in improvement cutting, thinning, methods of harvesting, pruning, farm forestry, natural reproduction, release cutting, growth and yield, and the other problems connected with

timber growing. The third objective is to maintain a complete set of inventory, cost, and return records for all studies so that the profitableness of each treatment can be accurately determined.

Much of the experimental work under way on the Forest has not reached the publication stage. At the same time, large numbers of visitors and guests express a wish to know more about the progress of the studies than can be obtained on a short visit. The present guide or progress report has been prepared to meet this desire. Naturally the information is subject to considerable modification as the studies progress. It should be remembered also that returns from the few well-stocked stands on the Forest cannot be applied directly to less well-stocked forests of the region, though they may indicate the values to be realized some years in the future.

The Southern Forest Experiment Station wishes to express its appreciation to the Crossett Lumber Company for providing the funds that made this publication possible.

R. R. Reynolds
June 1951

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The economic welfare and development of northern Louisiana and southern Arkansas is largely dependent upon the advancement made in managing the forests of this area. In the territory bounded by the Ouachita Mountains on the north, the Mississippi Delta on the east, Urania and Natchitoches, Louisiana, on the south, and the Texas and Oklahoma State lines on the west, better than two-thirds of the 15,000,000 acres are forested.

Shortleaf and loblolly pine stands—some of the most productive in the entire South—occupy about one-third of the forest, and another third is composed of these pines in mixture with upland hardwoods. Bottomland hardwoods make up about 20 percent of the forest, while the rest is upland hardwood, either pure or with a slight mixture of pine. Except in some of the bottomlands, the forests are second-growth.

The territory is checkered with small farms, but the low fertility of much of the soil for field crops and the employment offered by the increasing industrialization of the area have caused

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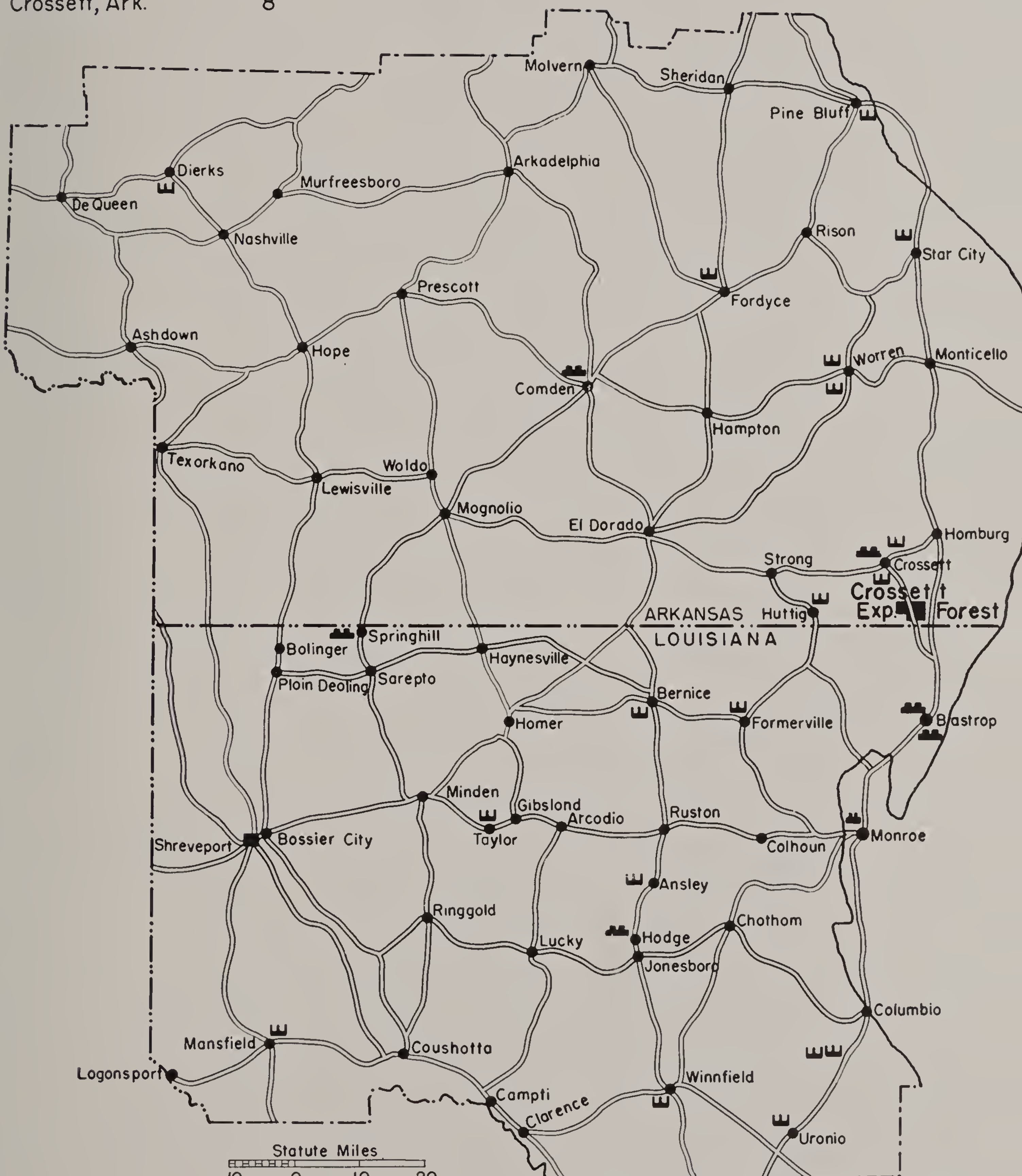
Territory served by the Crossett Experimental Forest. →

Distances to Crossett Exp. Forest

From	Miles
Birmingham, Ala.	351
Dallas, Texas	336
New Orleans, La.	314
Memphis, Tenn.	222
Jackson, Miss.	165
Monroe, La.	45
Crossett, Ark.	8

Pulp mills
Sawmills-40 MBF or more per day in 1946



many farms to be abandoned. Today a very large acreage that was once cropped is reverting to forest. About a quarter of the forest land is still on farms, but there is also a very sizeable percentage in large, privately owned industrial forests. Very little is in public ownership. Most of the larger and some of the smaller landowners are interested in forestry and are rapidly intensifying their management practices.

To serve the needs of the timber growers and users of this area, the Crossett Branch Station was established in 1934. At that time the Crossett Lumber Company deeded 1,680 acres to the Federal Government for an experimental forest with the provision that the Government would return the initial volume of timber to the company within twenty years. In 1942 the company leased 1,800 additional acres to the Government. Studies have also been established on other land belonging to the Crossett Lumber Company, and on holdings of the Urania Lumber Company at Urania, Louisiana.

THE EXPERIMENTAL FOREST. — The Crossett Experimental Forest is typical of the flatwoods country of south Arkansas and north Louisiana. It includes land from which the virgin timber was cut in 1915-16 and old farmsteads abandoned before the turn of the century. Since the virgin timber was cut to a 14-inch stump diameter and most of the old fields seeded in heavily to pine, all the Forest is now reasonably well stocked to pine, some of it quite large. Management is gradually converting the original shortleaf-loblolly pine-hardwood stands to a shortleaf loblolly pine type in which loblolly is increasingly dominant.

← *This virgin stand of loblolly and shortleaf pine averages 15,250 board feet (Doyle) per acre, and has trees in it 250 years old and up to 53 inches in diameter. Stands like these are about gone, but with good management second-growth forests can easily outstrip virgin stands in growh per acre per year, and can approach them in quality of timber.*

The forest is in Ashley County, eight miles south of Crossett on State Highway 133.

The land is gently rolling to flat with a number of small intermittent streams throughout the area. Elevations range from 160 to 180 feet above sea level. The soils are a heavy brownish-gray silt loam on the surface with a stiff brownish-red clay underneath. The entire area is classified as Richland silt loam.

The average annual precipitation for the past 35 years has been 51 inches, with monthly totals ranging from zero to 13 inches. Rainfall is usually greatest during the winter and spring months. July and August are often very dry. Snow is of minor consequence but sleet storms are often damaging.

The annual average temperature over a period of 25 years has been 63.9° F., with the highest about 112° F. and the lowest –9° F. Monthly means range from 44.9° in January to 81.6° in July and August. The average date of the last killing frost in the spring is March 30 and that of the first killing frost in the autumn is November 4. Thus the growing season averages 218 days.

ADMINISTRATION AND MARKETS. – Cutting operations and fire protection on the Forest are facilitated by a 15-mile network of roads. The Forest has direct radio and telephone connections with the fire protection system of the State of Arkansas and of the Crossett Lumber Company.

At present all products cut on the Forest are delivered to the Crossett Lumber Company in fulfillment of the terms of the deed and the lease. Management is facilitated by the fact that the Company's plants will take practically all species and nearly all parts of each tree. Two large sawmills cutting pine and hardwood logs, a large pulp mill using pine pulpwood,

and a hardwood distillation plant using low-quality hardwoods are located in Crossett. Although there is a creosoting plant in Crossett, the market for posts, poles, and piling is still largely undeveloped.

In order to control the operations closely and to provide complete cost records, all harvesting of forest products is carried out by U. S. Forest Service crews and equipment. Cutting proceeds the year around, with the average annual cut running to nearly 1,200,000 board feet of saw timber, 1,400 cords of pulpwood, and 120 units of chemical wood. To date, better than 80 percent of the volume of logs, pulpwood, and chemical wood present on the Forest (the original 1,680 acres) in 1937 has been cut and delivered to the Crossett Lumber Company. Even so, the volume on the area today is considerably more than when cutting first started.

THE RESEARCH PROGRAM. – Investigations are being conducted in forest management and forest economics. Many studies involve cost and return records, and must therefore be on a large enough scale so that cutting and value figures will be reliable. For this reason the Forest has been divided into 40-acre compartments, and a large percentage of the research is conducted on areas of this size. Many smaller studies, however, are also in progress. The large-scale studies are mapped on pages 29 and 30, and the small studies on page 31.

To provide an early and accurate measure of the effects of stand treatment upon the growth and yield of forest products, a 100-percent continuous-inventory system was adopted at the beginning of the experimental work on the Forest. The initiation of all studies undertaken on the Forest is preceded by a 100-percent inventory of all trees 3.5 inches and larger in diameter. If a compartment is being handled on a cutting-cycle basis, a second 100-percent inventory is made at the end of the cutting

cycle and before the second cut is made. Other studies are reinventoried every two, three, or five years regardless of when the harvest cutting may be made.

Where it is desirable to know the stocking by kinds of trees, the inventory is made by species and by 1-inch diameter classes. In most cases, however, the inventory is made by 1-inch diameter classes and by three or four species groups: (1) pine, (2) sweetgum and blackgum, (3) red and white oak, and (4) other merchantable hardwoods. Trees from 3.5 to 9.4 inches in d.b.h. (diameter at breast height, 4½ feet above the ground) are recorded only by diameter, while larger trees are tallied by diameter, number of 16-foot logs, and grade of each log. So that the growth information will be free of bias brought about by economic conditions, cruising has been and will be done to constant fixed top utilizations standards, rather than to variable standards fluctuating with market conditions. Generally, the minimum top size is 4 inches for pulpwood and 7.5 inches for sawlogs. Merchantable volume in tops above the 7.5-inch point is taken care of in the local volume tables used. All volume or stand records are computed in cubic feet inside bark, and are then converted, where desirable, to board measure.

SELECTIVE TIMBER MANAGEMENT

The virgin timber in the Crossett area was usually clear-cut to a 10- or 14-inch diameter limit. This was good business in stands where most of the trees were mature. Clear-cutting of the immature second-growth stands that developed following the removal of the virgin timber was something else. It produced an average log that was small, low in quality, and expensive to log and mill. But perhaps more important, clear-cutting removed a very large percentage of the trees at the time that they were rapidly increasing in volume and value. A system of management was needed that would permit the mills to be operated profitably on logs of good size and quality during the period that the badly run-down stands were being rehabilitated. Since it seemed possible that a type of selective timber management would accomplish most of these objectives, the cutting cycle study described below was one of the first studies undertaken.

CUTTING CYCLE STUDY. – Will light, frequent, selective cuttings increase growth enough to make up for the lower logging costs to be expected from heavier and less frequent cuts? How will frequent cuts affect reproduction? Answers to questions like these are sought in a study of the costs and returns that can be expected from the management of the essentially all-aged or all-diametered second-growth shortleaf-loblolly pine-hardwood stands through south Arkansas and north Louisiana. Additional objectives are to determine: (1) the most effective cutting cycle to use, and (2) the amount of growing stock necessary to produce the greatest growth per acre per year.

A selectively cut stand two years after the initial cut.

The same stand ten years later and after a second selective cut. The young pines in the foreground germinated in the opening made by the first cut.

The study, initiated in 1937, occupies 24 40-acre compartments, eight of which are cut on a 3-year cycle, eight on a 6-year cycle, and eight on a 9-year cycle. On compartments where the stand contains 10,000 feet (International ¼-inch rule) of sawlogs per acre at the end of the cycle, the volume of sawlogs cut is equal to the growth made over the period. Only part of the growth is cut from stands less fully stocked. The stocking of 10,000 feet has been arbitrarily assumed as ideal and is subject to revision as work progresses.

RESULTS TO DATE. – In order to permit the younger and smaller trees to develop, much of the volume removed at each cutting period is taken from trees 18 inches and larger in diameter. The average log produced over the first 10 years of the study was approximately 15 inches in diameter at the small end and averaged 109 board feet, International ¼-inch rule.

The average stand of pine sawlog material on the 958-acre study area when the study was started in 1937 was 4,870 board feet (International ¼-inch rule) in trees of sawlog size–11.5 inches d.b.h. and larger. From 1938 to 1947 an average of 1,755 board feet was cut per acre. This was 37 percent of the original volume in sawlog trees, yet the number of such trees had increased 20 percent by 1947. Pine trees 20 inches in diameter and larger increased by 60 percent during this same period. At the end of 1946 the average stand contained 6,253 board feet of sawlogs per acre, 30 percent more than when the study started.

Low-grade hardwoods made up 42 percent of the total basal area or the original stand. In the 4- to 9-inch diameter class, hardwoods were more numerous than pine. Over the first 10 years of the study more than 90 percent of the total cubic volume of this low-grade hardwood has been removed and has been replaced by pine.

Pine sawlog growing stock per acre in trees 11.5 inches

in diameter and larger, and average pine growth per acre per year for the 10-year period of the study, were as follows:

Cutting cycle	Growing stock after first cut	Growth per acre per year
	Board feet, International ¼-inch rule	
3-year	3,506	376
6-year	4,407	413
9-year	4,052	329

Pine sawlogs produced from 1938 to 1947 were 45 percent grade 1, 29 percent grade 2, and 26 percent grade 3.

The gross value of forest products produced over the 10-year period plus the value of additional volume added to growing stock was equal to $32.92 per acre at the 1938-47 stumpage prices. Total costs including taxes, fire protection, road maintenance and depreciation, timber marking, stand improvement, and general supervision averaged 0.72 per acre per year. Net returns were, therefore $2.57 per acre per year.

For the small owner who handles his own fire protection, timber marking, timber stand improvement, and supervision, the net returns would have been $2.86 per acre per year.

At 1949 prices the net returns, including value of increased volume of growing stock, would have been $7.24 per acre per year for the large owner and $7.55 for the small owner.

NATURAL AREAS. – In 1937 compartments 41 and 42 were set aside as natural areas. Though their stocking is slightly better than the average for the Forest, they will serve as check plots against which the results of management may be compared. These areas receive fire protection, but no cutting or salvage of any kind will be done on them.

So far, net hardwood growth in these natural stands has been practically nothing, because losses in over-mature trees have balanced new growth. Pine growth has averaged 5.2 percent, or 294 board feet per acre per year. By contrast, pines in similarly stocked managed stands in the study just described have grown at the rate of 418 board feet, or 10.1 percent, per acre per year.

	Pine	Hardwood
	Board feet International ¼-inch rule	
Volume per acre, 1937	5,640	2,222
Volume per acre, 1946	8,288	2,267
Growth per acre per year	294	5

The natural area. Cut to a 14-inch stump diameter limit in 1915-16, this area is now so encumbered with low-quality hardwoods that growth is far less than in managed stands. →

COMPARISON OF MANAGEMENT SYSTEMS

Practically all of the timber management in the territory of the Crossett Branch Station has been by the selection system. Selection management has been highly successful in converting unmanaged stands into fast-growing managed stands without increasing logging costs unduly or reducing the cut so greatly as to make sawmilling unprofitable. However, not all foresters and timberland owners are in accord concerning the merits of this system, which produces uneven-aged stands. Its critics argue that loblolly and shortleaf pine are sufficiently intolerant of shade as to be reproduced more easily in even-aged stands and with less expenditure for hardwood control. The proponents think that under the selection system there is no conversion problem, that only financially mature trees are removed, and that uncontrolled fires are not so dangerous, nor seed crop failure so disastrous, as in even-aged stands.

An objective test of these theories was designed and installed in 1948. Thirteen hundred and twenty acres are assigned to this study. Single-tree selection, group-selection, and the seed-tree methods of cutting are being tried. Half of the area devoted to each cutting method is being handled on a 30-year rotation with the objective of producing small products—pulpwood, poles, and small sawlogs. The other half is handled on a 60-year rotation with the objective of producing large products—large saw-

Pine stand being managed on a 60-year rotation under the seed-tree system. Thirteen seed trees per acre were left to regenerate the area. →

logs, piling, and veneer logs. Compartments managed on the single-tree selection system are cut every five years. In the group-selection compartments, groups average ½ acre in extent. On the seed-tree study, about 15 seed trees per acre have been left for the 60-year rotation and about 20 for the 30-year rotation.

Cutting began in 1948, with two of the 60-year compartments from each management method. So that fairly representative cost figures would be obtained, one compartment of each treatment was logged by a contractor and one by Forest Service crews.

The average cut on the seed-tree compartments was 6,112 board feet per acre. Group-selection compartments produced 1,583 board feet per acre, and single-tree selection compartments 2,189 board feet per acre. The average log size was 73 board feet for both the seed-tree and group-selection compartments, and 94 for the single-tree selection compartments. Total logging cost to the mills in Crossett averaged $9.46 per thousand board feet for the seed-tree compartments, $11.00 for the group-cutting compartments, and $8.96 for the selectively cut compartments.

← *Group-selection area being managed for large products. The group opening, which is about 1/2 acre in size, was made by cutting all pines of pulpwood size and over, and all sow-timber-size hardwoods. The small hardwoods were girdled after this picture was taken.*

NATURAL REPRODUCTION

In the management of loblolly and shortleaf pine it is important to understand fully the factors affecting the development and survival of reproduction. Some of these factors are the system of management employed, hardwood competition, fire, size of opening made in the overstory, litter depth, seed production of the overstory, amount of moisture and light available, and root competition.

A series of studies has been installed to test the effect of these factors.

DIRECT SEEDING. – Good crops of loblolly pine seed are infrequent and spotty. The idea of using direct seeding to obtain full stocking of loblolly pine reproduction in poor seed years has always intrigued the forester. To test the possibilities, 70 loblolly pine seed were sown in October 1938 on each of 108 1/1000-acre plots evenly distributed under six densities of old-field overstory. On one-third of these plots the ground cover, brush, and logging slash were undisturbed. On the second set, the brush and logging slash were removed and the ground was raked free of grass. The remaining third were cleared of all brush and logging slash, and the exposed mineral soil was cultivated to a depth of 3 inches. Half of the plots were fenced to keep out open-range cattle.

At the end of the first growing season the catch of seedlings was twice as great on plots where mineral soil was exposed as on the plots with the other treatments, but all had adequate stocking

to produce a well-stocked stand. Fenced plots had more seedlings than unfenced plots. Seedlings were tallest in the areas with less overstory or under openings in the overstory. The amount and type of overstory apparently had more effect upon the development and survival of pine seedlings than ground preparation or protection from grazing.

Additional studies of methods and means of securing good stocking from airplane and hand sowing of pine seed are under way.

GROWTH OF SEEDLINGS IN OPENINGS. — Knowledge of the minimum-size opening necessary for good survival and growth is important to the successful application of the group-selection system of management. In 1949 two 1/8-acre, two 1/4-acre,, and two 1/2-acre openings were cut in a 55-year-old old-field stand 105 feet in height. The survival and growth of pine seedlings from the 1947 seed crop will be recorded to determine how far into the opening the effect of the surrounding trees extends, what size of opening in the overstory results in the most successful development of pine reproduction, what size of opening is adequate to maintain satisfactory growth and survival of pine reproduction, and how location within the opening affects the development of pine reproduction.

EFFECTS OF COMPETITION UPON LOBLOLLY SEEDLINGS. — Hardwoods cause heavy mortality of pine seedlings and retard those that do survive. Is this because they shade the reproduction, or because they deplete soil moisture at critical times of the year, or because they deprive the seedlings of both moisture and nutrients? In an attempt to answer these questions, 48 plots, each with a 2-foot radius, were established in a stand of small hardwoods in 1949. Each plot contained one pine seedling from the 1947-48 seed crop.

On 24 plots the hardwoods were tied back so that sunlight

could reach the pines. On the other 24 plots the hardwoods were undisturbed. On both sets the plots were subdivided as follows:

Watered—trenched

Watered—not trenched

Not watered—trenched

Not watered—not trenched

First-year results indicated that competition for soil nutrients and water is more critical than competition for light. The trenches put around the pines to free them from competition with hardwood roots significantly increased pine height growth. Watering the plots when soil moisture dropped to 12 percent (as happened twice during the first summer) also appeared beneficial.

In the second year of the study, ample rainfall occurred year-long and therefore no test was obtained on the effects of soil moisture on pine growth. However, tying back the hardwoods but leaving their roots undisturbed greatly increased pine growth. Root competition for soil nutrients had no noticeable effect on the height growth of pines.

Final conclusions from this study are subject to further investigation under diverse sequences of weather conditions — especially under prolonged drought.

LITTER AND PINE REPRODUCTION. — The excellent germination and initial survival of pine seed falling on mineral soil has sometimes led to the conclusion that, to obtain adequate natural reproduction, litter must be removed by burning or by some mechanical means. To check on the soundness of this idea,

a series of 1/1000-acre plots was inventoried on a part of the Forest that has been unburned for at least 15 years.

On the Crossett Experimental Forest the depth of litter in second-growth shortleaf-loblolly pine-hardwood stands which are managed on the single-tree selection system, and from which fire has been excluded for 15 years or more, averages about 1.3 inches. The area sampled in 1948 had an average of 10,300 pine seedlings per acre from the excellent 1947 seed crop — more than enough to give adequate stocking. Where the litter had been largely removed — as in skid roads and logging roads — there were six times as many seedlings as where the litter was undisturbed.

Only under the tops of recently felled trees was the litter so heavy that it prevented the establishment of at least 7,000 seedlings per acre. These tops occupy only a small portion of areas logged under the selection system. In good seed years, therefore, no special seedbed preparation appears necessary under conditions similar to those on the study area. Additional study is needed to determine if pine litter hampers natural reseeding in light and medium seed years.

METHOD-OF-CUTTING STUDY. — One of the first studies established was a small-scale method-of-cutting study to test four radically different types of stand treatment: (1) clear-cutting of everything valuable on small blocks with reproduction obtained from the sides, (2) clear-cutting of sawlogs to a 12-inch diameter, (3) a light shelterwood or heavy seed-tree cut (about 15 trees left per acre), and (4) single-tree selection.

The objectives are to determine for each treatment (1) what growth and yield can be produced per acre, (2) what dif-

ficulties will be met in obtaining adequate pine reproduction, (3) what difficulties with low-quality hardwood will be encountered, and (4) what effect the treatment has upon quality of product.

Three 2.5-acre plots (series I) of each treatment were installed in well-stocked, fairly old stands in 1937. In 1942 another set of plots (series II) was established in younger stands. The selection plots have been cut every five years and the diameter-limit plots every ten years.

Merchantable material growing on these plots was last inventoried just before cutting in December 1947. Reproduction remeasurements were made during the winter of 1945-46 on the series I plots and in the winter of 1946-47 on the series II plots. Ten-year results for the series I plots and five-year results for the series II plots are shown in tables 1 and 2.

Volume growth has been much the best on the selection plots but surprisingly good on the diameter-limit plots. Good growth is, however, not to be expected for some years on the seed-tree and clear-cut plots. Pine reproduction has been best on the seed-tree plots but adequate on all plots.

Table 1.—*PINE SAWLOG VOLUME AND GROWTH PER ACRE, METHODS-OF-CUTTING-STUDY*

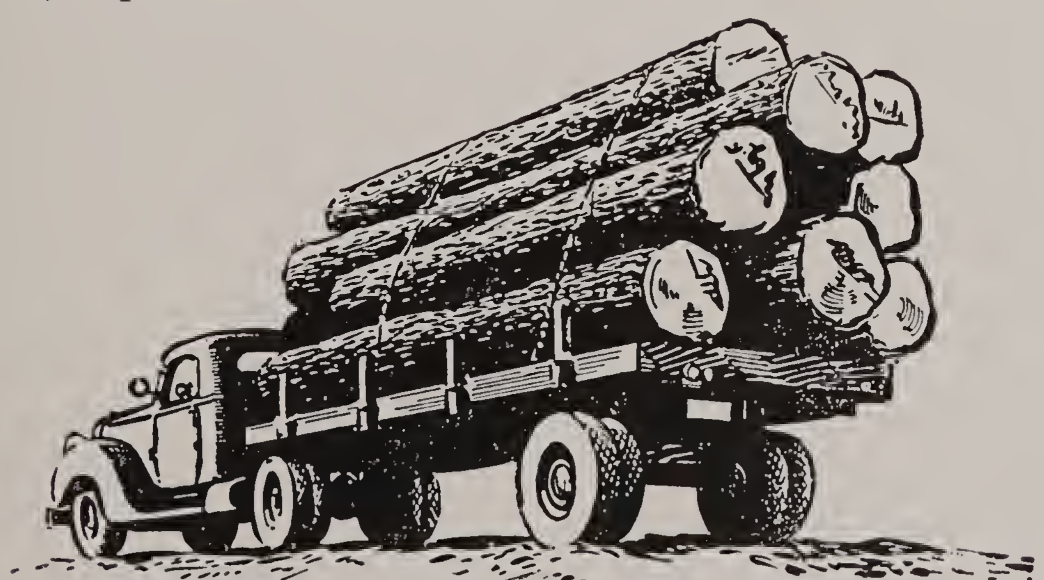
Treatment	Series I		Series II	
	Stand prior to cut in 1947	Growth per year	Stand prior to cut in 1947	Growth per year
	Board feet, International ¼-inch rule			
Selection	10,404	535	6,043	414
Seed-tree	3,798	166	2,858	193
Diameter-limit	3,712	353	1,503	216
Clear-cut	....	...	....	...

Table 2.—*PINE REPRODUCTION PER ACRE, METHODS-OF-CUTTING STUDY*

Treatment	Series I—1945		Series II—1946	
	Trees 0-0.49 inch d.b.h	Trees 0.5-3.49 inches d.b.h.	Trees 0-0.49 inch d.b.h	Trees 0.5-3.49 inches d.b.h.
	Number			
Selection	860	42	1,124	97
Seed-tree	6,310	474	3,500	221
Diameter-limit	3,040	450	1,081	99
Clear-cut	3,640	330	1,902	122

CONE PRODUCTION OF SMALL LOBLOLLY SEED TREES. — As the paper industry expands in the South, more and more of the pine lands can be expected to be managed for pulpwood under some even-aged system with a rotation of perhaps 30 years. Under such a short rotation the trees to be left as a seed source will necessarily be small—10 to 14 inches in diameter at best. Can trees of this size, grown in fairly dense stands, reseed the forest in reasonable time?

In 1949 several areas were clear-cut, leaving approximately 20 pine seed trees per acre 8 to 14 inches in d.b.h. On these areas the cone production will be observed on 56 loblolly pine trees to determine: (1) the seed-producing capacity of loblolly seed trees of these sizes, and (2) the type of seed tree which will yield the greatest number of cones in the shortest time (the trees in the study represent 3 crown density classes).



MANAGEMENT OF YOUNG PINE STANDS

Thousands of acres in the South have seeded in to dense stands of young pine.

To increase the growth of some of these stands, to maintain maximum growth in others, and to salvage trees that are doomed to die of suppression, there must be some thinning. At what age should thinning begin? What trees should be removed? What growing stock should be left? What method of density control should be used? These are problems on which reliable information is needed. Pruning selected trees in these young stands would produce crop trees of the very highest quality.

The four studies described below indicate the work that is now under way on the management of young well-stocked stands. Other studies are being planned or installed.

EFFECT OF DENSITY ON OLD-FIELD STANDS. — Approximately one million acres of the territory served by the Crossett Branch Station are in old-field stands of pine. All too often such stands are clear-cut or cut to a diameter limit just as they reach the size at which they begin to put on quality growth. How should such stands be managed to produce greatest returns? What tree spacing should be used at various stand ages? An excellent fully-stocked old-field stand of loblolly and shortleaf pine on the Forest was ideally suited to such a management study. When the study was installed in 1937 the stand was 44 years old and badly overcrowded. Six treatments were used, in

each of which high-quality sawlogs are to be the principal and final crop and pulpwood an intermediate crop:

1. Leave best 200 trees per acre. Average spacing 15 feet. Thin every 5 years.
2. Leave best 100 trees per acre. Average spacing 21 feet.
3. Leave best 70 trees per acre. Average spacing 25 feet.
4. Leave best 40 trees per acre. Average spacing 33 feet.
5. Leave all trees up to and including those 7.5 inches in d.b.h. In addition, leave good trees 9.6 d.b.h., these larger trees to be spaced about 50 feet apart.
6. Check plots, no cutting.

Volume growth, both cubic- and board-foot, has been best on the most lightly thinned plots (table 3). The maximum periodic annual growth attained was 1.1 cords on areas thinned in 1937 to 200 trees per acre (15- by 15-foot spacing) and thinned since then at 5-year intervals. This compares with a growth of 0.42 cord on the unthinned check plots. Diameter growth indicates that all but suppressed trees had recovered from overcrowding three years after the initial treatment.

Table 3.—*GROWTH PER ACRE IN OLD-FIELD STAND THINNED TO VARIOUS DENSITIES*

Original tree spacing (feet)	Volume						Basal area 1947
	Original 1937	Cut 1937-47	Present 1947	Growth per yr.	Present 1947	Growth per yr. 1942-47	
		Cords			Bd. ft.		Sq. ft.
15 x 15	36	21	27	1.10	8,136	628	75
21 x 21	44	28	24	.86	8,630	532	64
25 x 25	47	34	19	.70	7,522	441	50
33 x 33	40	32	12	.40	4,512	324	34
7.5-inch diameter limit	42	28	16	.22	3,422	195	50
Check	39	. .	43	.42	8,642	487	134

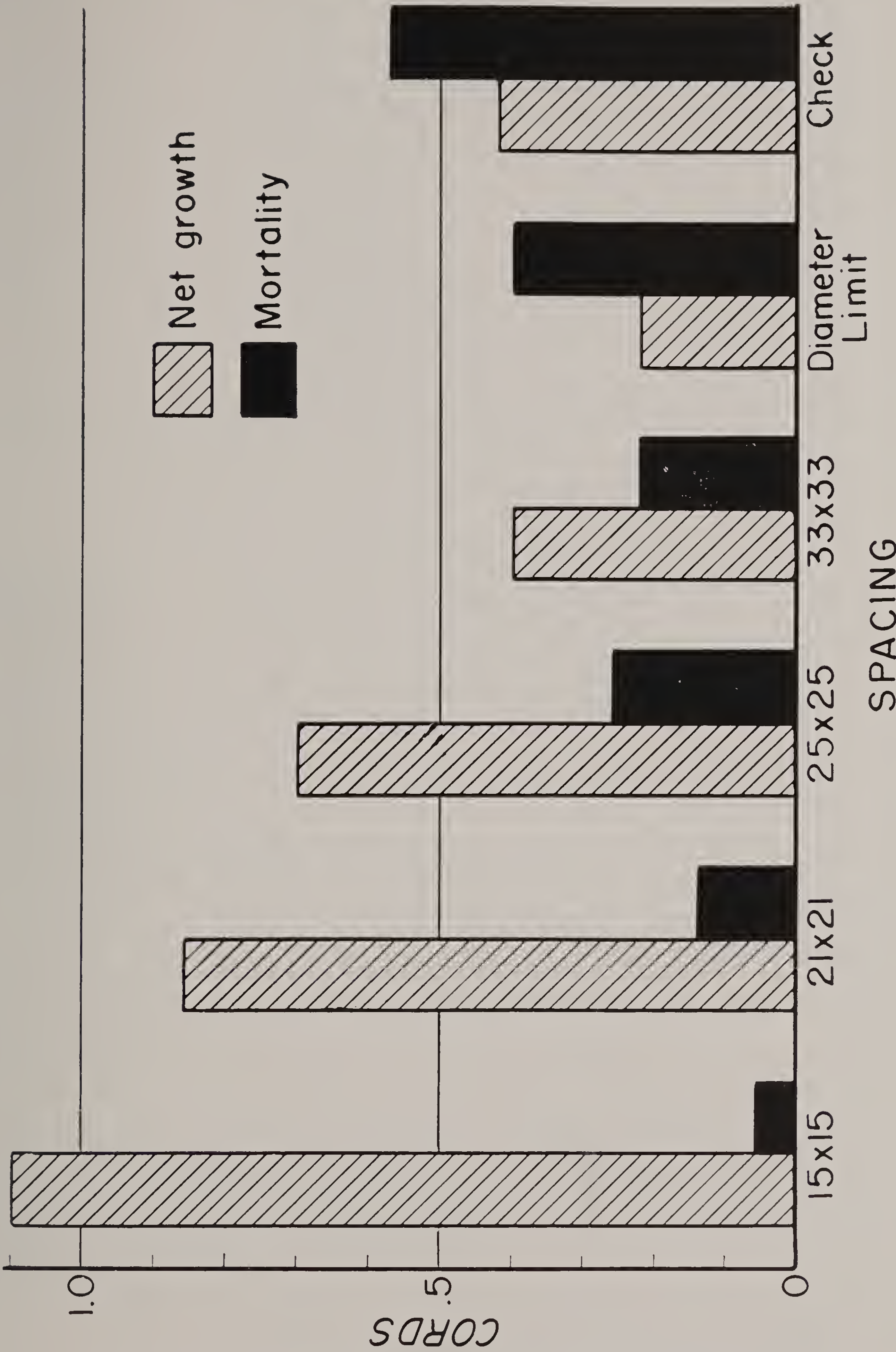
Sixty-four percent of the volume lost on both the treated plots and the check plots occurred among suppressed and intermediate trees less than 9 inches in diameter. In stands like this, frequent light thinnings are therefore recommended to keep mortality low while maintaining a good rate of growth.

Good reproduction from the 1939 seed crop has developed on all but the most lightly thinned and the check plots. It is satisfactory wherever 1942 basal area was less than 60 square feet, but is not needed except on the two most heavily thinned plots and on the diameter-limit plot.

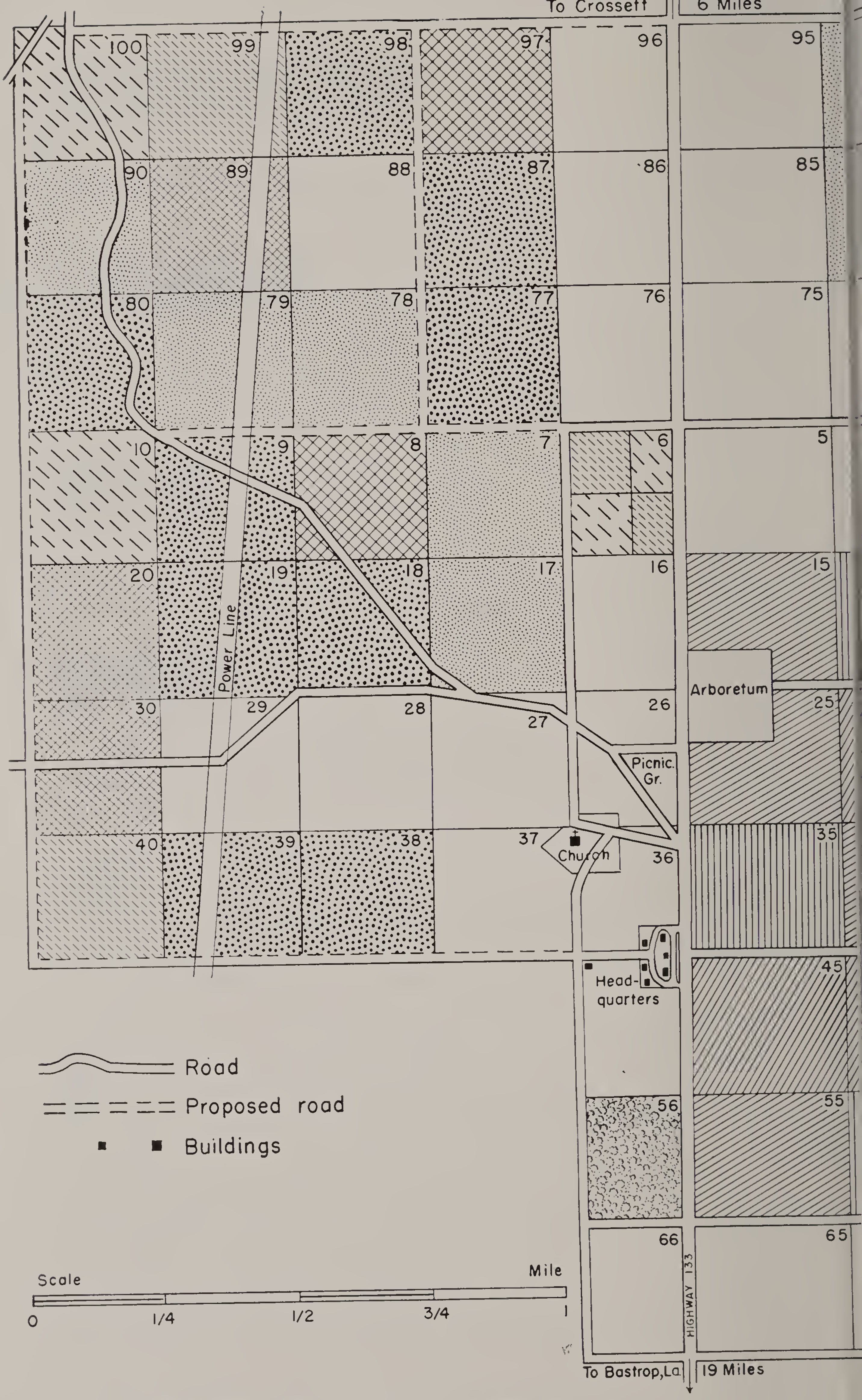
THINNING FROM ABOVE VS. THINNING FROM BELOW. – The Maxwell plots established at Urania, Louisiana, in 1915 constitute one of the earliest thinning studies in the South. Five ¼-acre plots in an old-field stand of loblolly pine which had seeded in 1908 were thinned as follows:

1. Heavy German thinning–removing the suppressed, intermediate, and a few of the codominant trees.
2. Crop-tree thinning–removed all the trees in the stand except a few dominants expected to make very rapid growth.
3. Light French thinning–removed all the merchantable, suppressed, and intermediate trees, together with approximately 20 percent of the dominant crown canopy.
4. Heavy French thinning–removed all the merchantable, suppressed, and intermediate trees, together with aproximately 30 percent of the dominant crown canopy.
5. Check–no thinning.

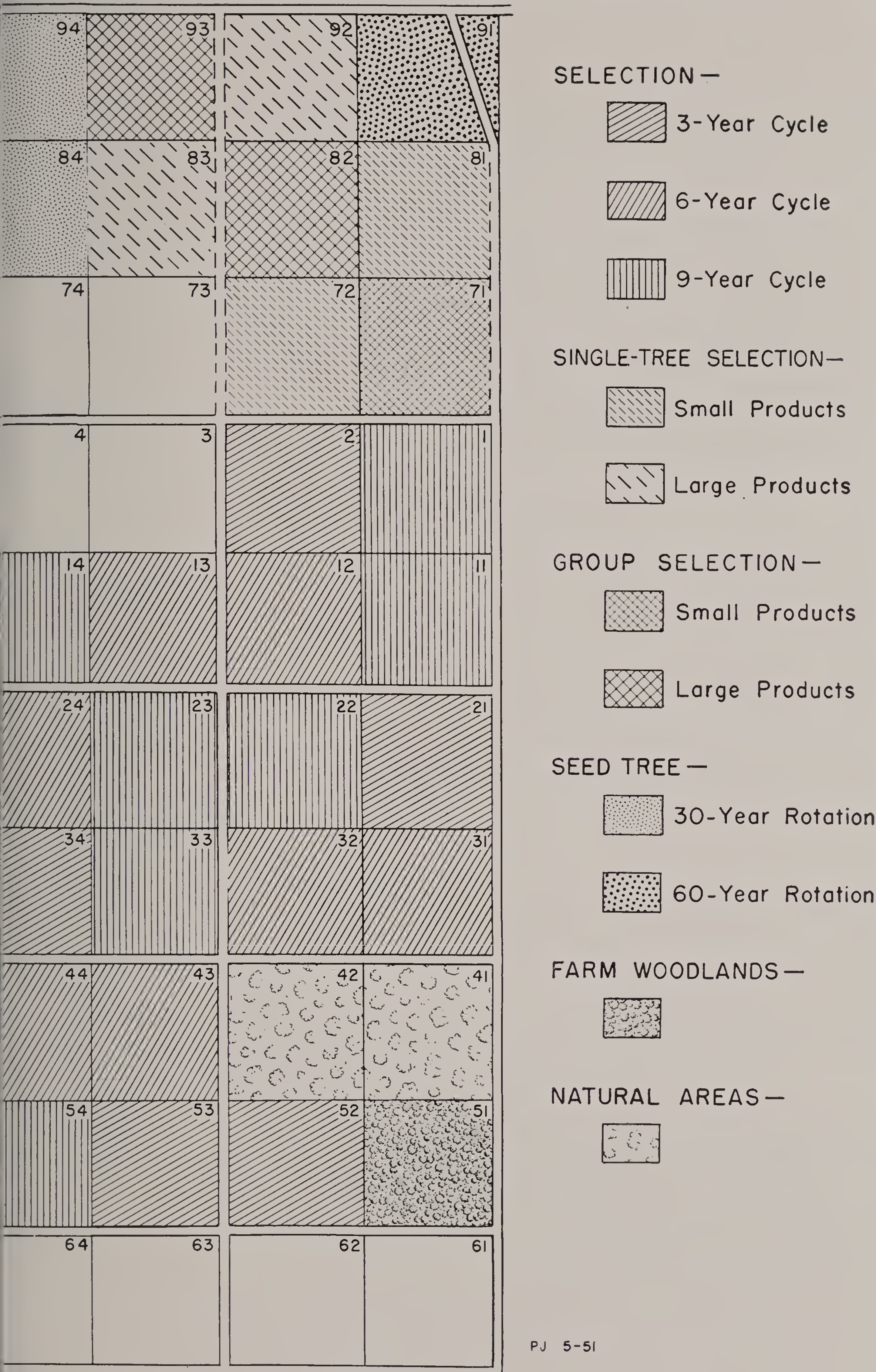
Up to 33 years of age the unthinned plot produced more net cubic volume of wood than any of the managed plots. For periods longer than 30 to 35 years, production of wood was increased by early thinnings beginning at 18 years. Over these



Ten years' growth and mortality in old-field shortleaf-loblolly pine stand first thinned at 44 years of age.



Forty-acre compartments on the Crossett Experimental Forest. For studies occupying less than a compartment, see map on next page.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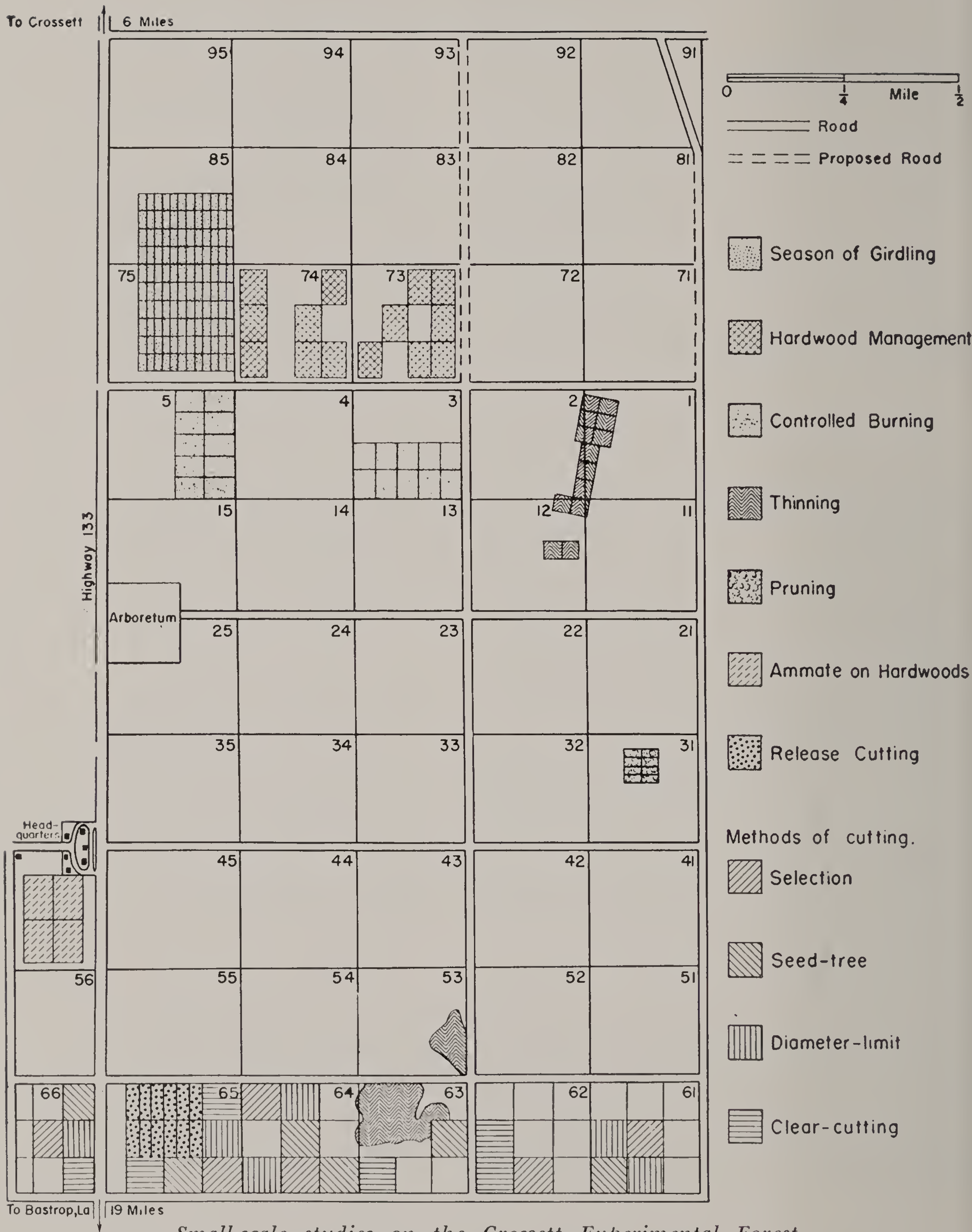
SELECTION—
3-Year Cycle
6-Year Cycle
9-Year Cycle
SINGLE-TREE SELECTION—
Small Products
Large Products
GROUP SELECTION—
Small Products
Large Products
SEED TREE—
30-Year Rotation
60-Year Rotation
FARM WOODLANDS—
NATURAL AREAS—
PJ 5-51



Small-scale studies on the Crossett Experimental Forest.

longer periods, maximum volume has thus far been produced by frequent thinnings from below, while best quality wood was attained by frequent light thinnings from above.

MANAGING SECOND-GROWTH PINES. – In thinning young, dense, second-growth pine stands, is it preferable to leave dominant trees (thin from below) or to keep the smaller and shorter but cleaner codominant or intermediate trees (thin from above)? A large-scale study on this subject was established in 1949. The study also seeks to determine how the volume and number of trees left per acre affect growth and yield.

In a 20-year-old stand averaging approximately 5.4 inches in diameter and located on a good site (index 90) 3 plots were thinned from above so as to leave 70 square feet of basal area per acre, 3 were thinned to leave 85 feet, and 3 to leave 100 feet. Each 5 years, until the stand reaches 60 years of age, all of these plots will be thinned back to these volumes. A fourth set of plots has been thinned from above to 70 square feet of basal area. On these plots some thinning will be done each 5 years, but the basal area will be allowed to build up gradually to 100 square feet. Four similiar sets of plots were laid out to test thinning from below.

One additional set of plots has been, and will in the future continue to be, thinned from both above and below according to the best judgment of the marker.

Finally, the whole study has been repeated in a well-stocked stand on a poorer site (site index about 73).

The first results will be obtained in 1954, but it will be 40 years before the study is completed.

PRUNING IN OLD-FIELD STANDS. – Many loblolly and shortleaf pine plantations and natural old-field stands fail to

A fully stocked, even-aged, 20-year-old pine stand before thinning. This stand is typical of those it is desired to develop under intensive management. Basal area is 120 square feet per acre. The stand needs its first thinning.

Same stand after being thinned to 82 square feet of basal area. The better trees now have ample room for rapid growth. The thinning was made at a profit, for the trees removed were large enough to sell for pulpwood.

prune themselves as rapidly as do natural second-growth stands. Artificial pruning in such stands at an early age may greatly increase the production of high-grade lumber. Three pruning studies are now under way — one at Crossett and two at Urania.

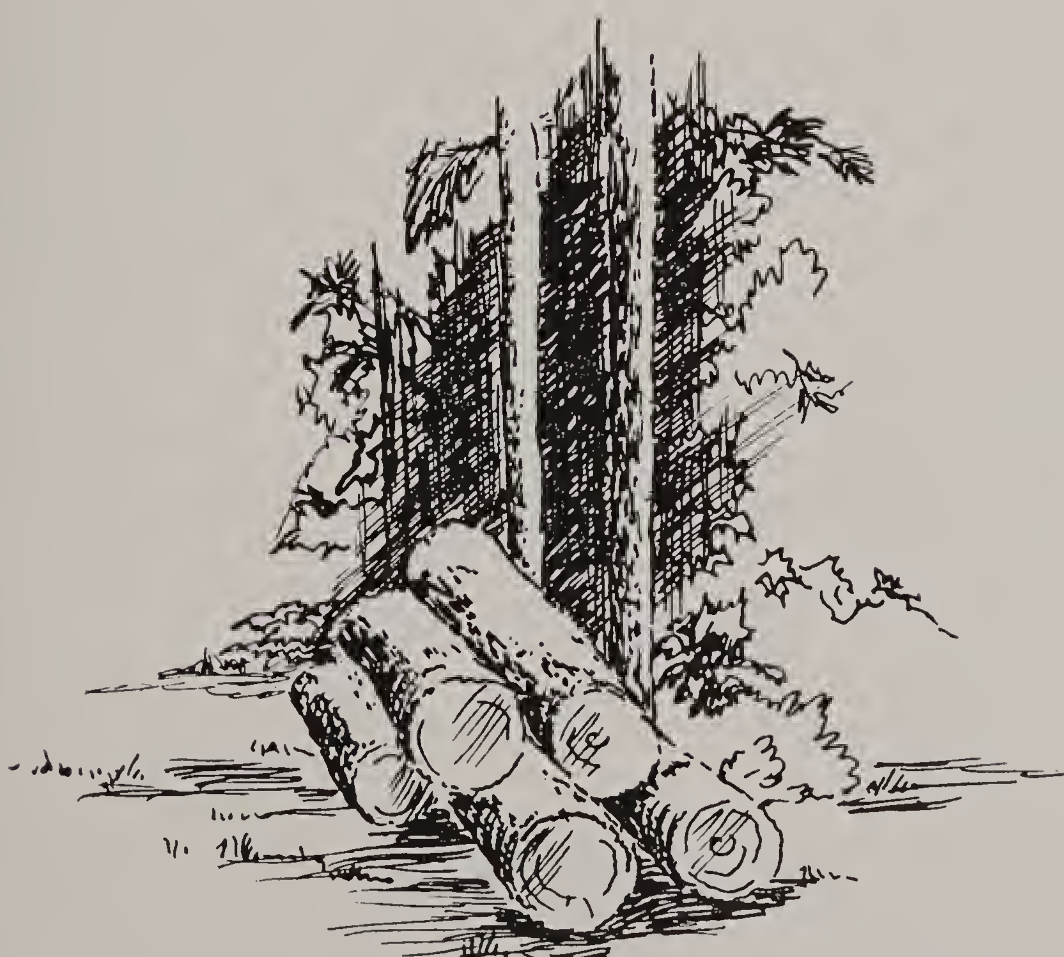
At Crossett, eight ½-acre plots were established in a 30-year-old old-field stand in 1939. One hundred and fifty trees per acre averaging 7.6 inches in diameter were selected as crop trees. On four of the plots these crop trees were pruned to a height of 25 feet. On the other four plots no trees were pruned. Although intermediate thinnings are to be made at 6-year intervals, final analysis of the benefits of pruning is to rest on a mill-scale study at age 60.

One study at Urania began in 1936, when thirteen 1/10-acre plots were established in a 6-year-old old-field stand. On three of the plots 100 to 150 selected crop trees per acre were pruned to about 8 feet in 1936 and to 17 feet in 1941. Three plots were thinned to 100 to 150 crop trees, but the trees were not pruned. Crop trees on the third series of plots were released by thinning adjacent trees, after which the crop trees were pruned. The remaining four plots were left untreated as a check. The thinned plots were last treated in 1948. A mill-scale study is to be made when the crop trees, which now average about 8 inches in diameter, reach 20 inches d.b.h.

The other pruning study at Urania was established in 1933 in a relatively open 11-year-old old-field stand. The trees were very limby, and on most of them the live crown extended to within 4 feet of the ground. On one ½-acre plot 137 trees were pruned to a height of 17 feet in 1933 and 20 of the best of these were pruned to a height of 34 feet in 1951. The trees on the other ½-acre plot were left unpruned. Both plots were given a non-commercial thinning in 1933. The pruned plot was again

thinned in 1942 and 1951. The unpruned plot was thinned in 1946 and 1951.

Results indicate that the pruning scars have healed within 5 years of the pruning date and that clear wood has been formed after about 1½ inches of diameter growth. The effect of the pruning will more accurately be determined from a mill-scale study of the logs produced by the pruned and unpruned trees after the trees have reached 18 to 20 inches in diameter.



THE CONTROL OF UPLAND HARDWOODS

Large numbers of low-grade, slow-growing hardwoods are seriously reducing the productive capacity of the shortleaf-loblolly pine-hardwood stands west of the Mississippi River. Of these hardwoods, the large ones are culls which were left behind when the merchantable trees were removed, or are the survivors of repeated fires before the days of fire protection. The smaller ones are often sound but have little or no market value because of small size and low grade. Removal of these low-quality hardwoods by cutting, girdling, or poisoning should be one of the first steps taken after timberland is placed under management.

With good fire protection and a source of seed, pine reproduction will become established even under a heavy hardwood overstory following good seed years. The reproduction withstands the hardwood competition for a few years, but if not released it gradually becomes stagnated and is soon crowded out by the hardwoods. Where the pine seedlings are 3 feet or more in height, girdling of the overstory trees is usually all that is necessary to secure a very good stand of pine in place of the hardwood, as the pine will outgrow any hardwood sprouts that develop. Girdling also suffices where hardwoods are 10 inches or more in diameter, for hardwoods of this size sprout very little.

Fire or heavy cutting of pine has left other pine sites

← *A girdled hardwood. Healthy pine reproduction is taking its place in the stand.*

with a heavy overstory of small low-grade hardwoods with no pine underneath. If such areas are to be converted to pine by planting or by natural or artificial seeding, special efforts must be made to keep sprouting of hardwoods to a minimum.

What intensity of release treatment should be used? What is the cost of girdling as compared to the cost of different methods of poisoning? Which method of applying poison best combines effectiveness with low cost? At what season of the year will girdling result in the least sprouting? These questions await answers.

COST OF GIRDLING OR FELLING HARDWOODS. – In a stand with hardwoods ranging in size from 1 to 29 inches and averaging 6 inches in diameter, hardwood trees over about 5 inches in diameter were girdled, and those smaller than 5 inches were cut, during August and September 1947. In order to determine cost by tree size, time and cost records were kept for the 5,400 trees treated.

Allowing $0.75 per hour for labor and $0.21 per hour for supervision and overhead, the cost of girdling red oak, post oak, hickory, and other hardwoods varied from 2.5 cents per tree for 6-inch trees to 5.5 cents per tree for 12-inch trees. Cost of felling small trees varied from 0.4 cent for 2-inch trees to 1.8 cents for 5-inch trees.

Twenty-two months after girdling, 61.6 percent of the trees bore sprouts. Of those trees that sprouted, however, very few were larger than 8 inches d.b.h. Twelve percent of the girdled trees still had live crowns, but one-third of the girdled trees were down. Crown-kill in post oak was lower than for red oak or sweetgum, but the sprouts on post oak were fewer and smaller. All in all, the treatment was very successful because sprouts reoccupied only 3 percent of the area that the girdled trees had formerly monopolized.

AMMATE FOR CONTROLLING HARDWODS. – Since World War II, Ammate (80 percent ammonium sulfamate) has been increasingly used in stand improvement work because it kills trees faster than girdling, results in less sprouting than either girdling or felling, and is nonpoisonous to deer, livestock, and humans. Two studies using Ammate have been established on the Forest. In the first study, installed in the fall of 1947, four 5-acre blocks were treated as follows:

1. Weak Ammate solution, 19.3 percent (2 pounds Ammate to one gallon water), applied in frills at easy chopping height.

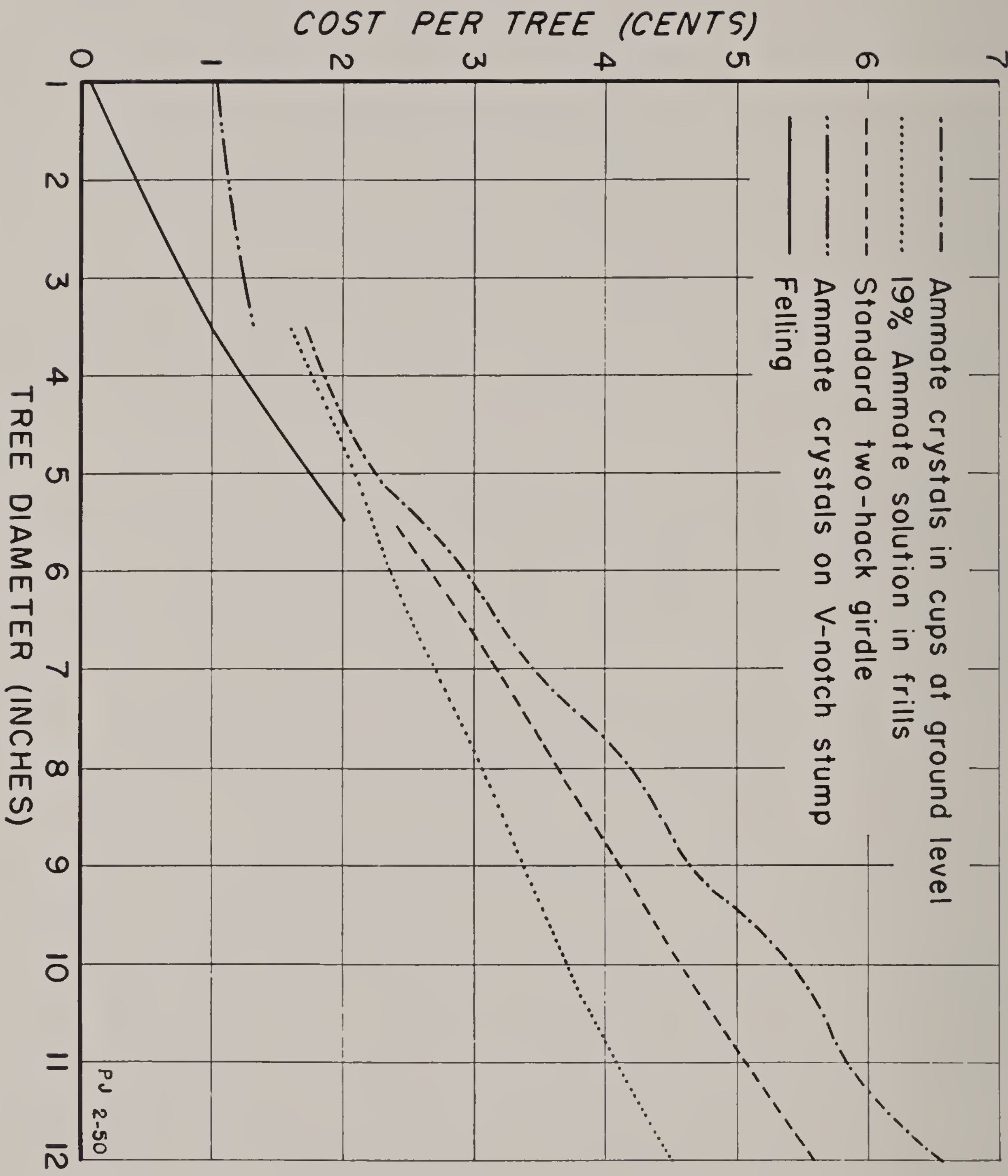
2. Strong Ammate solution, 37.5 percent (5 pounds Ammate to one gallon of water), applied in frills at easy chopping height. (A frill is a single line of overlapping downward ax cuts around the tree.)

3. Ammate crystals in "cups" (notches in the trunk, made with 2 strokes of an ax) near the ground line.

4. Ammate crystals in cups at easy chopping height, about 30 inches.

All hardwoods above 3.5 inches in d.b.h. (all dogwood regardless of size) were treated; hardwoods less than 3.5 inches d.b.h. were treated only if they were overtopping pine reproduction. Cups at ground line averaged 6 inches apart edge to edge, and cups at 30 inches averaged 4 to 5 inches apart. One heaping teaspoonful of Ammate crystals was poured into each cup. Frills were filled to the brim with Ammate solution. The poison was applied by the axman.

When the trees were examined in the fall of 1949, it was found that both 19.3 and 37.5 percent Ammate solution poured into frills had resulted in almost 100-percent crown kill. Crown



Costs of treating hardwoods, allowing 75c per hour for labor; 21c for supervision, transportation, and overhead; and 15c a pound for Ammate, where it was used. Allowance for delays and for walking from tree to tree is included. In the Ammate treatments, trees under 4 inches d.b.h. were chopped down and crystals were put on the stump top. Girdling was not used on trees under 6 inches in diameter, as felling was cheaper.

kill averaged considerably less for hardwoods that were treated by placing Ammate crystals in cups either at ground line or at 30 inches from the ground. Sprouting of the treated trees, however, was much less for cup-crystal treatment than for the frill-solution method.

Detailed results are summarized in the chart and in table 4. Trees were considered dead if they showed no sign of life above the point at which Ammate had been applied. In trees classed as heavily damaged, the top of the crown was dead, and the foliage was fairly scant. This degree of damage was often typified by feathering out along the bole.

Table 4.—*TWO-YEAR EFFECT OF AMMATE UPON UPLAND HARDWOODS 3.5 INCHES D.B.H. AND LARGER*

Treatment	Dead and heavily damaged	Sprouting	Average width of sprout clump	Cost per acre	Ammate used per acre
	Percent of treated trees		Feet	Dollars	Pounds
Crystals in cups at ground	77	11	2.4	4.25	12.4
Crystals in cups at 30 inches	62	9	2.0	3.80	12.4
Frill, 19.3 percent solution	98	77	4.7	3.39	3.1
Frill, 37.5 percent solution	100	68	4.4	4.08	7.7
Frill only	82	80	..	1.78	...
Two-hack girdle[2]	...	..	..	3.07	...

1. 190 trees per acre averaging 5.1 inches d.b.h. Includes cost of labor, Ammate, transportation of crew, and overhead.

2. Based on results of another study.

Recommended practice at present, where a good kill with little sprouting is desired, is to girdle hardwoods larger than 9 inches in diameter and to treat smaller trees with Ammate crystals in cups cut near the ground. Of 276 trees (9 inches and smaller) treated in this way, 94 percent were dead or heavily

damaged two years after treatment with very little sprouting. Many of the trees treated with Ammate crystals in cups at 30 inches above the ground line are now callusing over the cups, and this treatment cannot be recommended. Ammate solution in frills gives a quick, almost 100-percent crown kill and is effective where the pines undergoing release are at least 3 feet tall.

A second study was installed in 1950 to test and compare new methods of controlling hardwoods with and without Ammate. Three replications of each of the following treatments were established on ¼-acre plots.

HARDWOODS 3 TO 9 INCHES IN DIAMETER

1. Ammate crystals in cups spaced 6 inches edge to edge at ground.

2. Ammate crystals in cups spaced 4 inches edge to edge at 30 inches above the ground.

3. Ammate pellets in single-hack cups spaced 6 inches edge to edge at ground.

4. 10.7 percent solution (1 lb. Ammate per gallon of water) of Ammate in frill.

5. 19.3 percent solution of Ammate in frill.

6. 37.5 percent solution of Ammate in frill.

7. Frill untreated with Ammate solution.

8. Frill; trees still alive after two years to be treated with 19.3 percent solution.

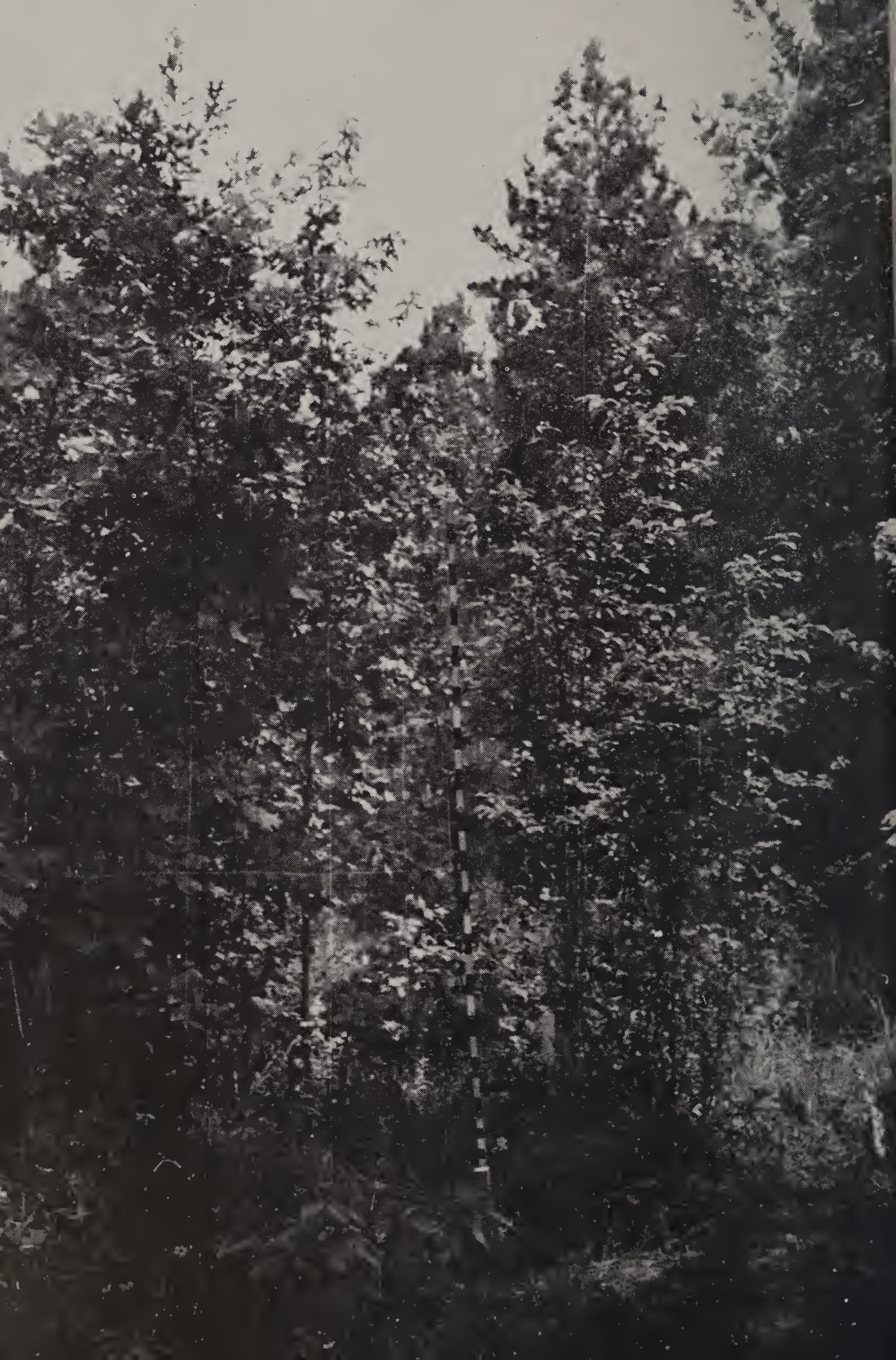
9. Girdle untreated with Ammate solution.

HARDWOODS 1 AND 2 INCHES IN DIAMETER

1. 49 percent solution of Ammate, (8 lbs. Ammate per gallon water) Cornell tool, one gash for 1-inch trees and two gashes for 2-inch trees.
2. 49 percent solution of Ammate, Cornell tool, two gashes for 1-inch trees and three gashes for 2-inch trees.
3. 32.4 percent solution of Ammate, (4 lbs. Ammate per gallon water) Cornell tool, one gash for 1-inch trees and two gashes for 2-inch trees.
4. 32.4 percent solution of Ammate, Cornell tool, two gashes for 1-inch trees and three-gashes for 2-inch trees.
5. 19.3 percent solution of Ammate, Cornell tool, one gash for 1-inch trees and three gashes for 2-inch trees.
6. 19.3 percent solution of Ammate, Cornell tool, two gashes for 1-inch trees and three gashes for 2-inch trees.
7. Cut off stem and apply one tablespoonful of Ammate crystals to stump.
8. Cut off stem.
9. Spray a solution of 0.6 percent 2-4-5-T in light Diesel oil on lowest 18 inches of stem.

SPROUTING AND SEASON OF GIRDLING. – To determine if there is some best season in which to girdle hardwoods, a study was begun in 1949 wherein the hardwood on a series of ½-acre plots is girdled at two-week intervals during the growing season and once a month for the rest of the year.

RELEASE CUTTING. – The practicality of timber stand improvement work is illustrated in a release cutting study installed in 1939 in a typical area where the low grade hardwood from 1 to 20 inches in diameter had taken over most of a good



pine site. Twelve hundred suppressed pine seedlings were present per acre but had little chance to get through the hardwood overstory.

Three different release treatments on a series of $1\frac{1}{4}$-acre plots removed varying amounts of hardwood. Under treatment 1, the competing hardwoods 6 inches d.b.h. and above were removed; under treatment 2, the competing hardwoods 2 inches d.b.h. and above were removed; while under treatment 3, the competing hardwoods 5 feet tall and larger were removed. Material large enough for pulpwood or chemical wood was marketed.

RESULTS. – The size and the number of hardwoods removed in each treatment are shown in table 5. It will be noted that the costs of removing the hardwoods in 1939 includes the work of felling, bucking, and cutting chemical wood and pulpwood. The value of these products, sold at the roadside, paid for most of the cost of the operation.

Most landowners, however, do not have markets for small hardwoods, but are forced to girdle or fell them and leave them in the woods. Table 5 therefore also shows what costs would be if trees 4 inches d.b.h. and larger were girdled and smaller ones were cut down. These costs have been determined at 1949 wage rates of $0.75 per hour plus $0.21 per hour for supervision and overhead.

Removing hardwoods 6 inches d.b.h. and larger released only 47 pine seedlings per acre, Treatments 2 and 3 released 571 and 695 pine seedlings. Treatment 1 was too light for the greatest benefits, whereas treatments 2 and 3 were almost equally effective in releasing pine.

← *Before treatment, the release-cutting area was dominated by hardwoods, although pine seed trees and advanced second-growth were scattered over the area.*

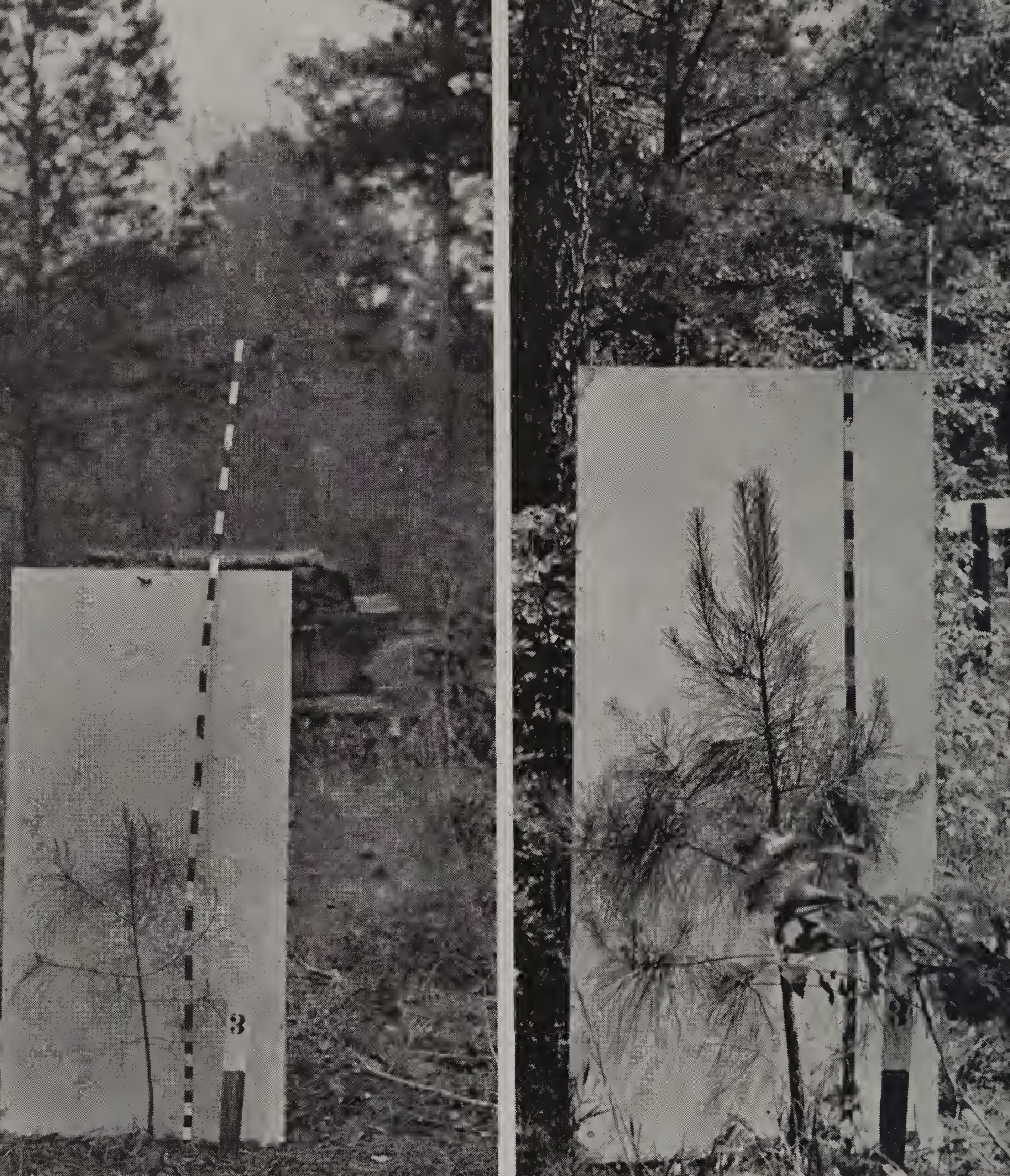
As shown in the pictures on pages 45 and 47, suppressed pine seedlings responded quickly to release. Of 138 released seedlings that were tagged for intensive study, only four died in the first 4 years of the study.

Table 5.—*COSTS OF HARDWOOD REMOVAL, AND VOLUME AND VALUE OF PINE GROWTH UNDER THREE DEGREES OF RELEASE*

Item	Treatment		
	1	2	3
Hardwoods treated in 1939			
Number per acre	15	136	432
Average d.b.h. (inches)	8.6	4.7	3.0
Costs per acre, 1939			
Cost of felling, bucking, cutting	$5.05	$7.43	$7.63
Roadside value of products	5.00	5.97	5.06
Net cost, 1939	.05	1.46	2.57
Pine volume thinned in 1949			
Cords	.19	1.51	1.62
Value	$0.38	$3.02	$3.24
Cost of cutting and girdling, 1949	.53	1.84	2.43
Net return	−0.15	+1.18	+0.81

Growth of released pine seedlings during the 10-year study period has been excellent on areas given treatment 2 and 3, but was unsatisfactory where only hardwoods 6 inches d.b.h. and larger were removed. Table 6 illustrates the stand development in each treatment. In treatments 2 and 3, there have been increases of 256 and 283 trees per acre in the 2- to 6-inch d.b.h.

← *Exactly same spot on release cutting area 10 years after treatment. Many pine that had been buried beneath the dense hardwood canopy are now pulpwood size or nearly so. This area was treated by removing any hardwoods 2 inches d.b.h. or larger that were competing with pine reproduction.*



Left.—Typical loblolly pine seedling which was released by cutting the competing hardwoods. Sparse, thin, droopy seedling was 2.0 feet tall when released in October 1939. In April 1940, when photo was taken, it was 2.8 feet tall.

Right.—By May 1941, or 1½ years after release, the tree was 4.6 feet tall and foliage was abundant and vigorous.

Seedling that was suppressed 10 years ago was 26.0 feet tall and 3.0 inches d.b.h. in January 1950.

classes as contrasted to an increase of 122 in treatment 1. In treatment 1, only a few seedlings have reached merchantable size, while both of the heavier treatments have a good stand of pines, many of which are pulpwood size.

In treatments 2 and 3, released seedlings have grown so rapidly that a thinning was made in 1949—just 10 years after treatment. Although it would have been at least four more years before sufficient volume could be removed from the plots in treatment 1 to make a thinning economically feasible, all plots have been thinned to obtain a comparison of the returns. The volume and value of the products from the thinnings are given in table 5. The returns shown in the table are only from those trees that were small enough in 1939 to be affected by the release cutting.

Table 6—*STAND DEVELOPMENT DURING THE 10-YEAR STUDY PERIOD, BY TREATMENTS — 1939 TO 1949*

D.b.h. class (inches)	Number of pine per acre		
	1939	1949	Increase from 1939 to 1949
Treatment 1—Competing hardwoods 6 inches d.b.h. and larger removed			
2	9	84	75
3	15	41	26
4	12	25	13
5	13	17	4
6	8	12	4
7+	39	75	36
Treatment 2—Competing hardwoods 2 inches d.b.h. and larger removed			
2	17	120	103
3	13	84	71
4	9	51	42
5	11	37	26
6	7	21	14
7+	34	74	40

Treatment 3–Competing hardwoods 5 feet tall and over removed			
2	28	140	112
3	21	99	78
4	15	64	49
5	15	43	28
6	13	29	16
7+	33	78	45

Treatment 1, which was not sufficiently intensive, shows a loss of $0.15 per acre. In treatments 2 and 3, the returns from the thinning have more than repaid the hardwood removal costs. Moreover, the excellent stand of pine now present on these plots will yield valuable cuts of pulpwood, poles, and eventually sawlogs at regular intervals for 50 years or more. The striking feature of this study is that an area almost completely dominated by low-value hardwoods was converted to a nice stand of pine at a small cost.

IMPROVEMENT CUTTING IN ALL-AGED STANDS. – In stands with sawlog trees. – At the time that the virgin pine-hardwood stands around Urania were cut to a diameter limit, many large hardwoods had fire scars or other defects that made them unmerchantable. Thirty years later, hardwoods, chiefly those in the large diameter classes, were suppressing and crowding many of the young second-growth loblolly pines which had become established. In 1933 two plots of 2 acres each were selected for study; one was left untreated while a combination improvement-harvest cut was made on the other.

The treatment consisted of cutting or girdling all hardwoods over 9.5 inches d.b.h. All smaller hardwoods between 4.0 and 9.5 inches d.b.h. that were seriously interfering with better pine were also deadened. All pine over 16.5 inches d.b.h., except the most vigorous, straightest, highest-quality individuals not seriously interfering with their younger neighbors, were cut for saw-

logs. Pines between 4.0 and 16.4 inches d.b.h. were cut for pulpwood or sawlogs if they were defective or were crowding better trees.

The improvement cut removed 1,220 board feet of sawlogs (International ¼-inch rule) and 4.1 cords of pulpwood per acre, leaving a stand of 2,308 feet of sawlogs in trees 10 inches d.b.h. and above and 5.4 cords of pulpwood in 5- to 9-inch trees. The check plot had a volume of 3,902 feet of sawlogs and 9.0 cords in pulpwood-size trees per acre. Twenty hardwoods ranging in diameter from 10 to 27 inches d.b.h. were girdled on the treated plot while 19 hardwoods per acre of the same general size class were left on the check plot.

The average annual growth per acre for the first 15 years after treatment has been 50 percent better in the managed stand —487 board feet as against 322 feet on the check plot. During this period, annual growth in the 4- to 9-inch trees and the tops of sawlog trees has been 0.26 cord per acre on the treated plot, and 0.18 cord on the check plot.

IN STANDS OF CORDWOOD SIZE.—Following the cutting of the virgin pine timber in the Crossett Branch Station territory, many stands came back heavily to pulpwood-sized pine and cordwood-sized hardwood. In such stands combining an early and light pulpwood cut with an improvement cut which removed the low-grade hardwood was almost unheard of a few years ago. To demonstrate the practicality of such a cut, a reasonably well stocked but unmanaged 40-acre compartment was divided into 8 plots. Three treatments were prescribed:

> *Treatment 1*—An improvement cut in the pine, removing rough and defective trees and thinning dense clumps of merchantable young trees. All hardwoods 4 inches d.b.h. and larger were removed.

Treatment 2—Same treatment as 1, but in addition hardwoods under 4 inches d.b.h. were cut where they were overtopping pine or where pine reproduction was desired.
Treatment 3—Check plots, no treatment.

The improvement cuts were made in 1945. They removed an average of 3.1 units of hardwood chemical wood and 2.1 cords of pine pulpwood per acre from the treated plots. An additional 1.3 cords per acre of cull hardwoods were girdled. The residual stand of pine averaged 10.9 cords per acre on the treated plots and 16.1 cords per acre on the untreated plots. Stumpage value of the products removed in 1945 averaged $3.62 per acre. Girdling and cutting of the unmerchantable hardwoods cost $1.88 per acre. Thus, the net returns after putting the stand into good condiion averaged $1.74 per acre.

In treatment 1, yearly growth per acre between 1945 and 1950 was 319 board feet of logs for trees 9.5 inches and larger, or 1.2 cords of pulpwood for trees of all sizes. On plots in treatment 2, annual growth was 360 board feet of logs or 1.4 cords of pulpwood for trees of all sizes. Growth on the uncut check plots was 274 board feet of logs or 0.98 cord of pulpwood per acre per year.

MANAGEMENT OF UPLAND OAK

Present management policies regarding shortleaf-loblolly pine-hardwood stands invariably recommend that hardwoods be removed or rigidly controlled to favor pine. This is done in the belief that hardwoods cannot be managed as profitably as pine. Actually, no one knows the potential of the better species of upland oak if given every advantage now accorded pine. The possibility of using artificial pruning to produce hardwood timber of high quality and value cannot be overlooked, especially when one considers the increasing scarcity of good hardwood timber. An additional inducement for the retention of some hardwoods in the stand is that hardwood leaf litter may be needed to maintain satisfactory soil conditions.

A study testing the possibilities of upland oak management was initiated in 1949. Four treatments have been used:

1. All pine removed and hardwood crop trees artificially pruned.
2. All pine removed and hardwood crop trees permitted to prune naturally.
3. Pine managed in conjunction with selected hardwood crop trees. Hardwood crop trees permitted to prune naturally.
4. Conversion to pure pine by removal of hardwoods.

← *In this part of the upland hardwood management study, selected hardwoods were pruned and all pine was removed. The object is to measure the quality and growth potential of white oak and southern red oak.*

Each of the treatments is being tested on three 2-acre plots. In addition, two 2-acre plots have been left untreated as natural areas. The selection system of management is being employed. The hardwoods are red and white oaks in the 4- to 10-inch class, although very good trees over 10 inches have also been retained. Improvement and harvest cuts will be made at 5-year intervals. Hardwood crop trees will be pruned to a height of two logs—33 feet. Soil changes brought about by conversion of the stands to pure pine or pure hardwood will be measured.

FARM FORESTRY

Approximately 20 per cent of all forest land in the Crossett Branch territory is owned by farmers. The average is 28 acres per farm. Thus, in this area the amount of the average farm income will depend to a very real degree on how well these owners manage their woodlands. In order to assist them in determining the best practices, the Crossett Branch set up a farm woodland study as one of its first projects.

In 1937, two areas of approximately 40 acres each were selected. One tract (compartment 51) was quite well stocked when the study was started and was used to determine the possible returns from farm woodlands once they are built up to desirable stocking. The second area (compartment 56) was poorly stocked with pines of poor quality, and much of it was covered with low-grade hardwoods. It was typical of many rundown farm forests.

One of the objects of the study was to see if a timber crop could be harvested annually. Accordingly, a cut of either logs, pulpwood, acidwood, or a combination of all products has been made annually from compartments 51 and 56 since 1937 and 1938, respectively. In addition, a cut of firewood and posts has been made on compartment 51 annually and three cuts of firewood have been made from compartment 56.

RESULTS.—The results on the better stocked tract have been given in a series of annual reports. Over the first 13 years, 161,000 board feet of logs, 294 cords of pulpwood, 228 cords of fuel wood, and 418 fence posts have been cut from this tract.

These products had a stumpage value of $2,851. Delivered to the mill or market they were worth $8,443. Moreover, the timber stand has improved and the forest today is in far better condition than when cutting started.

About 52 man-days per year are necessary to cut and deliver the annual harvest from the well-stocked forty. This would provide almost full time off-season employment for most farmers. The gross return for this labor (with no deduction for stumpage) would be better than $1.50 per hour. Net return for labor after deducting for taxes, fire protection, 4 percent interest on $1,000 investment, and other out-of-pocket expenses (but no return for stumpage as such) is better than $1.25 per hour of labor expended in producing the crop. This forty has shown that timber can be as much an annual crop as corn, potatoes, or cotton.

On the badly stocked forty (compartment 56), some salable products have been cut each year in order to pay taxes and other expenses while the stands are being built up. Almost all low-grade hardwoods have now been eliminated and an excellent stand of young pine now covers practically all the area.

From 1938 through 1950, 49,000 feet of sawlogs, 148 cords of pulpwood, 105 cords of chemical wood, 53 cords of firewood, and 121 fence posts were cut. These products had a total stumpage value of $1,314 and a market value of $3,895. This is equivalent to a stumpage return of $3.22 and a market value of $9.55 per acre per year. While the returns have not been large, they have more than taken care of all overhead and management costs while the stands were being placed in good condition and the growing stock of valuable trees was built up. Between 1938 and 1950, the volume of pine saw timber increased 1,600 board feet per acre, or from 1,900 to 3,500 board feet. It is expected that

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← *The good farm forestry forty. Annual crops forever.*

this improvement in amount of growing stock will be faster in the years to come, and that annual earnings will soon be much better.

TOTAL VOLUME OF TIMBER CUT TO DATE

The total volume of timber cut on the Crossett Experimental Forest since its establishment is 7,746,000 board feet of sawlogs and 13,000 cords of pulpwood. Of this, 4,200,000 board feet and 9,000 cords came from the original 1,680 acres (Unit I), on which cutting began in 1937. The balance is from the 1,800 acres (Unit 2) acquired, and on which cutting first began in 1942. As the growing stock has been built up and the area under management expanded, the volume of the cut has naturally increased each year. The cutting, skidding, loading, and hauling of the products produced annually on the Forest now require a year-round crew of 10 men, exclusive of supervisory personnel.

Since management started in 1937 hardwood growing stock was purposely reduced by cutting by about 600 board feet per acre. Pine volume in saw-timber trees increased 1,700 board feet, while pine pulpwood volume decreased about a cord per acre. Present annual growth on both units of the Forest is estimated to be about 1,218,000 board feet. As the stands are built up still further and the allowable cut increased, the forest should support a larger crew of loggers—possibly 15 men or one to every 232 acres. At the same time, the number of men employed in the processing plants will increase. It is not hard to envision a well-stocked pine-hardwood forest in this type eventually supporting one woods or mill job for every 50 acres.

ADDITIONAL STUDIES

A great many other studies of forest management, sawmilling, or utilization practices have been undertaken since the Crossett Branch was first established. The more important of those that have been completed and on which publications or manuscripts are available are:

1. Pulpwood and log production costs as affected by type of road.

2. Mortality of loblolly and shortleaf pine following hail damage.

3. Growth loss due to sawfly defoliation.

4. Natural mortality in managed stands.

5. Growth rate on managed sawlog stands.

6. Returns from managed all-aged stands over the 1938-47 period.

7. Costs of forest management in south Arkansas.

8. Selective logging and milling study.

9. Costs of producing logs and pulpwood in long vs. short lengths.

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Visitors are welcome at any time either for guided tours of

the experimental plots or for consultation with members of the staff. For further information regarding the research program and results to date, please contact the Officer in Charge, Southern Forest Experiment Station, Crossett Branch Station, Crossett, Arkansas.

NOTES

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